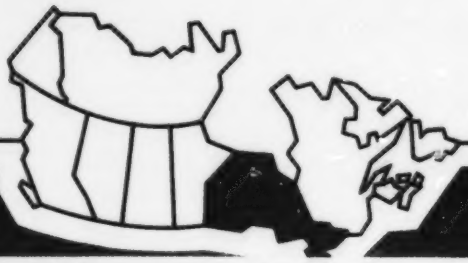
Environment Canada | Environnement Canada
Canadian Forestry Service | Service canadien des forêts

Black Spruce Regeneration Trials Near Nipigon, Ontario:

Planting Versus Seeding, Lowlands Versus Uplands, Clearcut Versus Strip Cut

J. E. Wood and J. K. Jeglum



Information Report O-X-361
Great Lakes Forest Research Centre

Environment Canada | Environnement Canada
2022805D VOL ISS 361 1984
EXC # 001

INFORMATION REPORT (GREAT LAKES FOREST RESEARCH CENTRE)
OOFF

85-2327/

THE GREAT LAKES FOREST RESEARCH CENTRE

The Great Lakes Forest Research Centre is one of six regional establishments located across Canada and operated by the Canadian Forestry Service. The overall objective of the Service is to promote the preservation, enhancement and wise use of a healthy, attractive and bountiful forest resource and terrestrial environment for the economic and social benefit of all Canadians. The Centre pursues this objective by conducting two major programs: research and technical services and forestry development. Both programs address major problems affecting forest management and the forest environment primarily in Ontario, but because of the transprovincial nature of the forest resource, many elements of our research program are of national significance.

Forestry problems are continually assessed by the Canada-Ontario Joint Forestry Research Committee, made up chiefly of senior members of the Centre and the Ontario Ministry of Natural Resources. The Committee ensures that the research resources of both agencies are deployed in a coordinated, cooperative manner and that the results of research are effectively transmitted to the forest managers in order to improve forest production and protection, and the quality of the environment.

Staff of the forestry development program negotiate and administer federal-provincial cost-sharing agreements with the province of Ontario, conduct economic studies, and implement job creation programs in the forest sector. Again, this requires close cooperation with the Ontario Ministry of Natural Resources and with other provincial and federal agencies concerned with the forest sector.

Close working relations are also maintained by the Centre with educational institutions specializing in forestry and the biological sciences, with the forest industry, and with other forestry organizations in the province.

The Centre recognizes that forested land must be managed in the best public interest, not only for the wood production essential to our economy but also for the recreational purposes that are so important to our social well-being. These goals must be achieved in a manner that will maintain or improve the quality of the forest environment and preserve it for generations to come.

BLACK SPRUCE REGENERATION TRIALS NEAR NIPIGON, ONTARIO: PLANTING VERSUS SEEDING, LOWLANDS VERSUS UPLANDS, CLEARCUT VERSUS STRIP CUT

J.E. WOOD AND J.K. JEGLUM

GREAT LAKES FOREST RESEARCH CENTRE

CANADIAN FORESTRY SERVICE

DEPARTMENT OF THE ENVIRONMENT

1984

INFORMATION REPORT O-X-361

©Minister of Supply and Services Canada 1984
Catalogue No. Fo46-14/361E
ISBN 0-662-13348-X
ISSN 0822-210X

Additional copies of this publication are available at no charge from:

Great Lakes Forest Research Centre
Canadian Forestry Service
Department of the Environment
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5N7

ABSTRACT

This report presents fifth-year survival, stocking, and height growth results from a black spruce *(Picea mariana* [Mill.] B.S.P.) regeneration trial near Nipigon, Ontario. Two stock types (bare-root stock and Japanese paperpots) and two seeding treatments (bare seed and sheltered seed) were studied on upland seedbeds (feather moss and mineral soil) and lowland seedbeds *(Sphagnum* and dark peat) in a clearcut and in 20-m-wide, first-cut strips.

Planting either bare-root or container stock on upland mineral soil seedbeds yielded the best results in terms of survival and height growth. The best seeding option was spot seeding on mineral soil seedbeds in strip cuts. Feather moss (primarily *Pleurozium schreberi* [Brid.] Mitt.) was an extremely poor seedbed with less than 15% stocking after five years. On mineral soil seedbeds, seed shelters increased seedspot stocking by 32% on a clearcut and by 15% on strip cuts. Heavy vegetative competition on the lowlands in comparison with that on the uplands reduced height growth of planted trees. Graminoid competition and flooding on the dark peat seedbeds were heavier on strip cuts than on clearcuts, and consequently the performance of planted and seeded trees was poorer on the former.

RÉSUMÉ

Ce rapport présente les résultats après cinq ans d'une étude sur la survie, la densité et la croissance en hauteur d'une régénération expérimentale d'épinette noire *(Picea mariana* [Mill.] B.S.P.), près de Nipigon, en Ontario. Deux types de matériels (à racines nues et en "paperpots" japonais) et deux modes d'ensemencement (exposé et abrité) ont été étudiés sur substrat de hautes terres (hypnacées et sol minéral) et de basses terres *(Sphagnum* et tourbe foncée), sur un terrain soumis à une coupe à blanc et dans des bandes de 20 m de largeur soumises à une première coupe.

La survie et la croissance en hauteur ont été les meilleures, quel que soit le matériel, sur le sol minéral de hautes terres. La meilleure modalité d'ensemencement a été en placeaux, sur sol minéral dans des bandes coupées. Les hypnacées (principalement *Pleurozium schreberi* [Brid.] Mitt.) constituaient un substrat extrêmement pauvre, pourva à moins de 15% après cinq ans. Sur le sol minéral, les abris à semences ont favorisé la densité de 32%, sur le terrain coupé à blanc, et de 15%, dans les bandes. Dans les basses terres, la forte concurrence végétale, comparativement aux stations de hautes terres, a réduit la survie et la croissance en hauteur des arbres plantés. La concurrence de la végétation apparentée aux graminées et l'engorgement du substrat de tourbe foncée étaient plus intenses dans les bandes que sur les terrains coupés à blanc; les arbres plantés et ensemencés ont donc moins bien fait dans le premier cas que dans le second.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to C.R. Mattice for establishing the experiment, F.W. Curtis for technical assistance, J.B. Scarratt and A. Wynia for providing the planting stock, J. Gorniak for drafting figures and D.W. Beilhartz and N. Bailey for their assistance with data processing and analysis.

Data collection in 1980 and 1982 was funded through the Canada-Ontario Forest Management Subsidiary Agreement. The authors wish to thank Amik Forest Consultants and Arbex Forest Development Company Limited for their work under this agreement.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
STUDY AREA	1
METHODS	3
RESULTS	6
Survival and Stocking	6
Total and Incremental Height Growth	9
Vegetative Competition	11
DISCUSSION	15
CONCLUSIONS AND RECOMMENDATIONS	17
LITERATURE CITED	18

Cover Photo: Area II, 20-m wide first-cut strip.

INTRODUCTION

Planting is currently the most common method of regenerating black spruce (*Picea mariana* [Mill.] B.S.P.) cutover lands in Ontario. However, site conditions (e.g., shallow soil uplands, organic soils), high costs, and shortages of labor and planting stock frequently limit the areas that can be planted (Fraser 1980). Within these limits, natural or artificial seeding may be the only practicable alternatives to planting. Strip cutting is one method of retaining the natural seed source and thereby encouraging natural regeneration. However, when the leave strips are harvested it may be necessary to regenerate them by planting or direct seeding. Because of the large quantities of seed required in broadcast seeding, spot seeding may be a more feasible means of regenerating these strips than broadcast seeding. Planting or direct seeding may also be required on large unrestricted clearcuts where a natural seed source is lacking.

In 1978 a small trial was established to evaluate four artificial regeneration options and to investigate seedbed/seedling relationships on shallow-soiled upland and lowland black spruce forest sites. This trial was established in a clearcut and in 20-m-wide first-cut strips. The regeneration options tested were planting (bare-root and paperpot stock) and direct seeding (bare seed and sheltered seedspots). The selected seedbeds were mineral soil and feather moss on the uplands and *Sphagnum* and dark peat on the lowlands. In this report fifth-year survival (stocking for seedspots) and height growth results are presented for trees in all treatment combinations.

This trial is part of a larger long-term cooperative study of strip clearcutting in shallow soil upland black spruce/Schreber's Feather Moss forest near Nipigon, Ontario. Further background information on this study is given elsewhere (Jeglum 1980, 1982, 1983; Ketcheson 1982).

STUDY AREA

The clearcut plots on the Thimble Creek Road (Area I) are located approximately 30 km east of Beardmore and 40 km east of Lake Nipigon (Fig. 1). The strip-cut plots are located on the Gorge Creek Road in the Peck Lake area (Area II) 20 km southeast of Beardmore. The plots are separated by about 25 km. Both areas are in the Central Plateau Section of the Boreal Forest Region (Rowe 1972).

The climatic conditions in the area have been previously described by Jeglum (1980, 1982) and may be summarized briefly as follows: mean maximum and minimum temperatures for July, 23° and 11° C, respectively; mean annual growing season 158 days; and mean annual precipitation 737 mm, of which 406 mm occur from May through September.

Because general soil and site conditions have already been characterized in detail (Jeglum 1980), only specific study areas are described here. The Area I clearcut site included a plot on a fresh crest site, and a plot in a wet peaty drainageway; in both cases the main soil matrix was silty to very fine sand with cobbles, stones, and boulders. The crest site had a 6-cm-thick fibrimor humus layer over mineral soil in excess of 85 cm deep. The drainageway site had a 50-cm-deep organic layer over mineral soil.

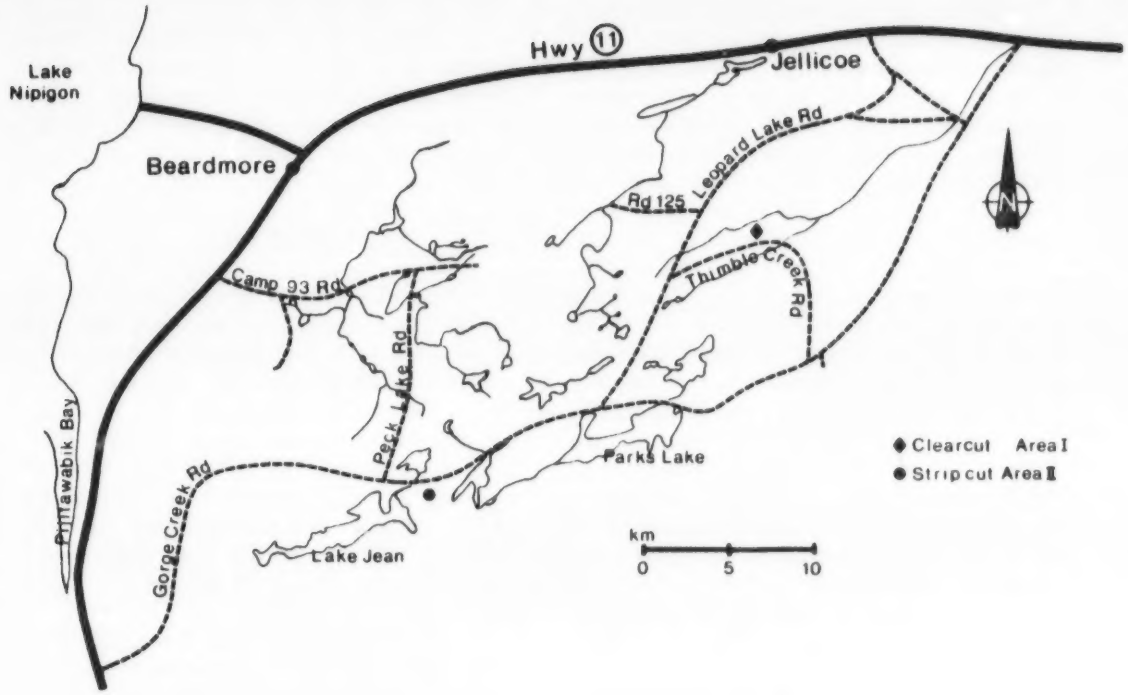


Figure 1. Location of clearcut (Area I) and strip-cut (Area II) plots in relation to Beardmore, Ontario.

Area I was harvested in an alternate 40-m strip clearcut pattern. The first strips were cut in 1975, and the leave strips in 1977. The forest cover prior to cutting on the upland plot consisted of black spruce (60%), balsam fir *(Abies balsamea* [L.] Mill.) (20%), and trembling aspen *(Populus tremuloides* Michx.) (20%). On the lowlands, the stand consisted of black spruce (95%) and balsam fir (5%). No scarification was conducted in Area I. Only softwoods were harvested; hardwoods were left as residuals.

In Area II, the first-cut strips were harvested in 1976-1977. The previous forest cover was black spruce (90%) and balsam fir (10%). Both the first-cut and residual strips were 20 m wide oriented north to south. Planting and seeding trials were conducted in the first-cut strips; the residual strips were left standing for the duration of this experiment. Both lowland and upland plots were interspersed among five separate strips. The soil texture in the strip cuts was silty to very fine sand, with a fresh-to-wet soil moisture regime. Cobbles, stones, and boulders were again abundant and bedrock outcrops were common. The upland site had a 6-cm-thick fibrimor humus layer over mineral soil generally less than 50 cm deep. The lowland site had a 50-cm-

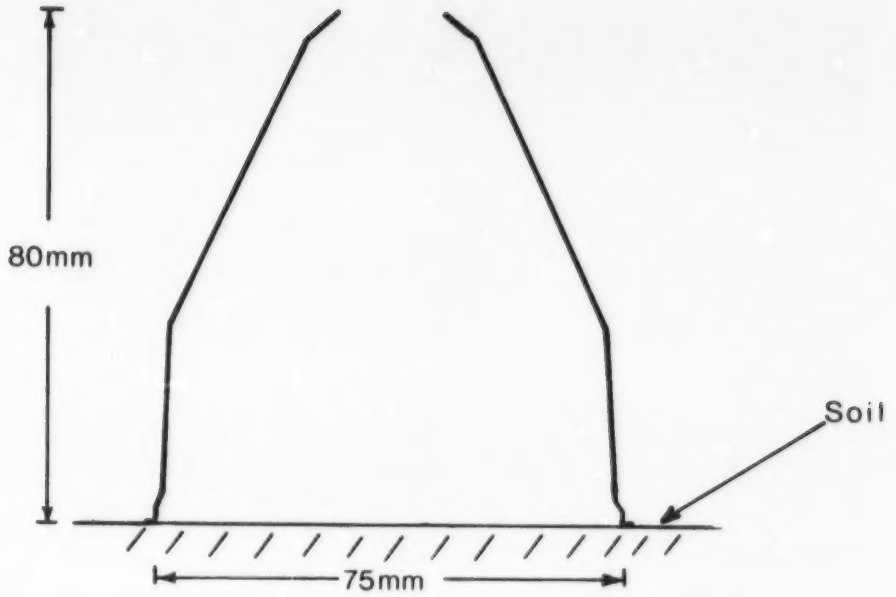


Figure 2. Semi-transparent plastic seed shelters used in the experiment.

deep organic mat over shallow mineral soil. There was little elevational difference between the upland and lowland plots on this site. The lowland positions were somewhat wetter on average than the lowland positions in Area I. Scarification was performed in these strips in the summer of 1976 with a TTS disc trencher.

METHODS

In both Area I and Area II, trees were planted and seedspots were established on both upland and lowland sites. A total of four planting/seedspot techniques were used. The two planting stock types were 3+0 bareroot and 408 Japanese paperpots. The two seeding methods were bare seed and sheltered seedspots. Each bare or sheltered seedspot was sown with eight seeds. The shelters[1] were plastic, semi-transparent and conical (Fig. 2).

On the shallow-soil upland black spruce/Schreber's Feather Moss sites the two most commonly occurring seedbeds were (i) mineral soil, usually exposed through logging or scarification, and (ii) undisturbed feather moss (Fig. 3). Feather moss tended to be drier and more yellow-green in the clearcuts, moister and greener in the strip cuts. On the lowland sites two commonly occurring seedbeds were (i) well decomposed dark peat and muck, the result of logging damage or scarification machinery churning up the dark humus and muck, and (ii) living *Sphagnum* moss or *Sphagnum* peat (Fig. 4). On each of these seedbeds all four planting/seeding techniques were established (Fig. 5). The mineral soil seedbeds included some that had a shallow organic veneer from the bottom of the organic mat over the mineral soil. Frequently these seedbeds were created by scuffing with the boot, especially in Area I where there was no scarification.

1 Manufactured by Työväline Espoo, Finland

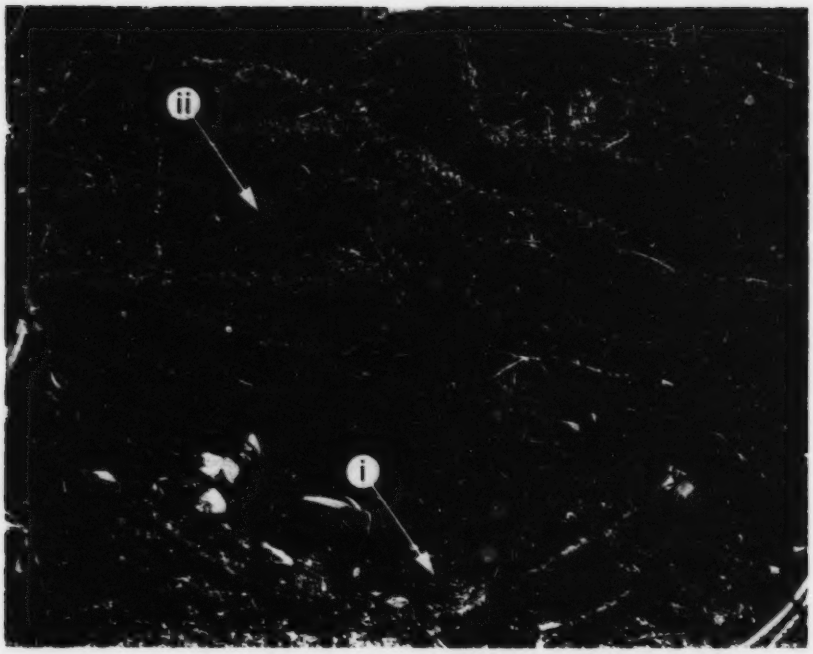


Figure 3. Upland seedbeds at establishment (1978): (i) exposed mineral soil, and (ii) undisturbed feather moss.

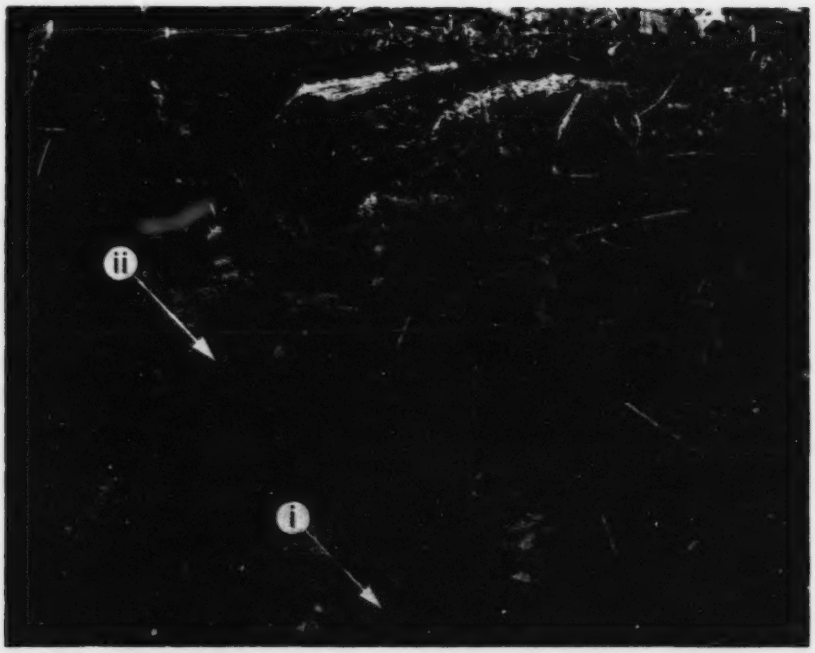


Figure 4. Lowland seedbeds at establishment (1978): (i) dark peat, and (ii) living *Sphagnum* moss.

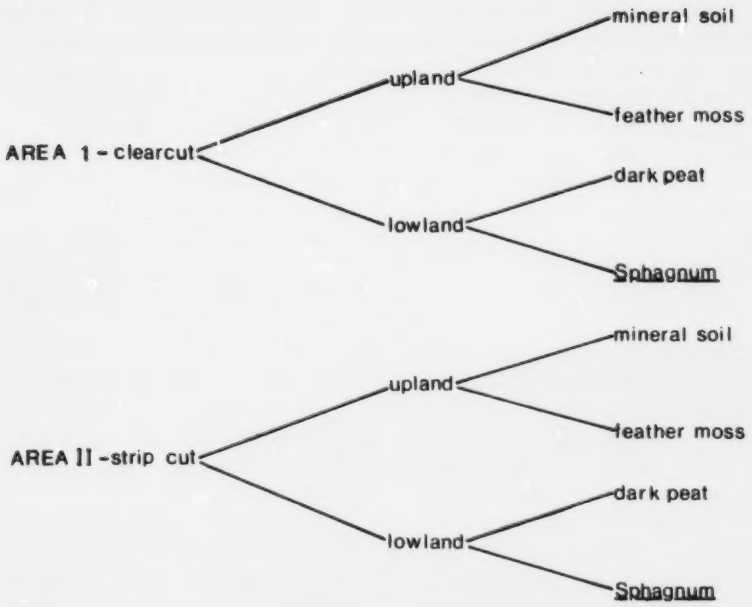


Figure 5. Seedbed/cutting method combinations.

Each planting/seeding treatment was replicated from three to five times on each seedbed/cutting method combination. There were about 25 planted trees or seedspots per replicate.

Seeding on the strip cuts was carried out in mid-June, while all planting and clearcut seeding treatments were established 28-29 June, 1978. The 3+0 bare-root seedling stock was raised at the Thunder Bay Forest Station, Thunder Bay, Ontario. The seedlings were fresh-lifted from the nursery beds on 23 June and cool-stored (2-4° C) at the nursery until transported to the field. The paperpots were raised at the Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario. This was current-year stock, which had been sown in the greenhouse in February 1978.

At planting, a sample of 50 bare-root and 60 paperpot trees was selected for analysis of morphological characteristics (Table 1). The following morphological features were measured: shoot length, root area index (RAI) (Morrison and Armson 1968), shoot:root ratio based on oven-dry weight, root-collar diameter, and top and root oven-dry weights. According to Reese and Sadreika's (1979) description of bare-root shipping and cull stock, plantable 3+0 seedling stock should have a RAI of at least 30 cm^2. The bare-root stock planted in this trial had a RAI of only 24.7 cm^2. The paperpots were morphologically "well balanced" at outplanting.[2]

---

[2] Anon. 1982. Forest management manual for crown lands. N.B. Dep. Nat. Resour. 176 p. (unpubl.)

Table 1. Morphological characteristics of bare-root and paperpot stock at time of outplanting (1978).

Stock type	Sample size (n)	Shoot length (cm)	RAI (cm^2)	Shoot: root ratio[a]	Root-collar diameter (mm)	Total oven-dry weight (g)
3+0 bare-root	50	33.4	24.7	4.2	4.4	5.8
408 paperpot	60	17.4	6.1	1.9	1.6	1.1

[a] Based on oven-dry weights.

Each planted tree was assessed for survival and each seedspot for stocking. A seedspot was classed as stocked if it contained one or more living germinates. Height growth was assessed in the fall of the first, second, third, and fifth growing seasons. If either the sheltered or the bare seedspots contained more than one live tree the tallest tree was measured. During several of the assessments the type of vegetation surrounding each of the planted trees or seedspots was recorded. Ocular estimates of vegetational cover were made five years after cutting in 0.5-m x 2.0-m quadrats in the clearcut area and strips where the experiment was conducted (Jeglum 1980).

RESULTS

Survival and Stocking

Uplands: Differences in survival of planted stock and stocking of seedspots over the five growing seasons were greater in the strip cuts than in the clearcut, owing to relatively high first-year values in the strip cuts (Table 2).

Survival values in 1982 were similar for planted stock in the clearcut and strip cuts (Table 2). Both bare seed and sheltered seedspots had higher stocking on mineral soil in strip cuts than in the clearcut.

Over all, the performance of the planted stock was superior to that of the seedspots (Table 2). The mean survival of planted stock in 1982 for the clearcut and strip cuts was 77%, whereas the mean stocking for seedspots was 33%. The paperpots always had slightly higher survival than the bare-root stock. On the same seedbeds the sheltered seed always had higher seedspot stocking than did the bare seed.

The planted stock showed better survival on mineral soil than on feather moss (Table 2). The two seedspot treatments always achieved higher stocking on mineral soil than on feather moss.

Lowlands: Survival always dropped over the five growing seasons (Table 3). The greatest reductions over time were generally associated with the seedspots, owing to greater mortality of the tiny germinates.

There were few differences in survival in 1982 for planted stock on the clearcut and strip cuts, except for the poorer performance of paperpots on dark peat in the strip cuts (Table 3). For the seedspot treatments on *Sphagnum*, there was higher

Table 2. Survival (%) of planted stock and percentage stocking of seedspots--upland seedbeds, clearcut and strip cuts, 1978 and 1982 assessments. Percentages are based on about 100 trees/seedspot (range 96 to 102).

Planted stock or seedspots	Clearcut		Strip cuts		Significance of[a] Chi^2		
	1978	1982	1978	1982	'A'	'B'	'C'
3+0 bare-root							
1. mineral soil	85	79	93	82	NS	*	NS
2. feather moss	69	55	78	66	NS	NS	NS
408 paperpot							
3. mineral soil	97	94	98	86	NS	**	NS
4. feather moss	79	75	97	80	NS	**	NS
Bare seed							
5. mineral soil	37	29	77	66	NS	*	**
6. feather moss	12	6	0	1	NS	NS	NS
Sheltered seed							
7. mineral soil	55	61	94	81	NS	**	**
8. feather moss	14	14	5	6	NS	NS	NS
Significance of[a] Chi^2							
'D' 1,2,3,4:5,6,7,8		**		**			
'E' 1:2		**		**			
3:4		**		NS			
5:6		**		**			
7:8		**		**			

[a] Application of multi-way contingency tables and likelihood ratio test (G^2) would have been statistically more appropriate: however, Chi^2 test of independence was used here because of simplicity and ease of interpretation of results.

'A' - represents Chi^2 comparisons for clearcut percentages--1978, '79, '80 and '82.

'B' - represents Chi^2 comparisons for strip cut percentages--1978, '79, '80 and '82.

'C' - represents Chi^2 comparisons for 1982 data for the clearcut and strip cuts.

'D' - represents Chi^2 comparisons for 1982 data for planted and seeded treatments.

'E' - represents Chi^2 comparisons for 1982 data for individual seedbed comparisons.

* - Chi^2 significant at 5% level.

** - Chi^2 significant at 1% level.

NS - Chi^2 not significant.

Table 3. Survival (%) of planted stock and percentage stocking of seedspots--lowland seedbeds, clearcut and strip cuts, 1978 and 1982 assessments. Percentages are based on about 100 trees/seedspot (range 73 to 125).

Planted stock seedspots	Clearcut		Strip cuts		Significance of Chi^2		
	1978	1982	1978	1982	'A'	'B'	'C'
3+0 bare-root							
1. dark peat	99	72	99	65	**	**	NS
2. *Sphagnum*	96	71	98	79	**	**	NS
408 paperpot							
3. dark peat	98	81	98	67	**	**	*
4. *Sphagnum*	95	88	93	82	NS	*	NS
Bare seed							
5. dark peat	64	36	84	21	**	**	*
6. *Sphagnum*	40	36	67	48	*	NS	NS
Sheltered seed							
7. dark peat	69	40	92	31	**	**	NS
8. *Sphagnum*	63	23	96	47	**	**	**
Significance of Chi^2							
'D' 1,2,3,4:5,6,7,8		**		**			
'E' 1:2		NS		NS			
3:4		NS		*			
5:6		NS		**			
7:8		*		*			

'A' - represents Chi^2 comparisons for clearcut percentages--1978, '79, '80, and '82.
'B' - represents Chi^2 comparisons for strip cut percentages--1978, '79, '80, and '82.
'C' - represents Chi^2 comparisons for 1982 data for the clearcut and strip cuts.
'D' - represents Chi^2 comparisons for 1982 data for planted and seeded treatments.
'E' - represents Chi^2 comparisons for 1982 data for individual seedbed comparisons.
* - Chi^2 significant at 5% level.
** - Chi^2 significant at 1% level.
NS - Chi^2 not significant.

stocking in the strip cuts than in the clearcut areas whereas on dark peat there was higher stocking in the clearcut areas than in the strip cuts.

Planted trees performed better than trees originating from seedspots (Table 3). Survival of the planted stock on dark peat and *Sphagnum* seedbeds in 1982 for the clearcut and strip cuts combined averaged 76%; stocking of seedspots (with comparable values being used) was 35%. Paperpots had better survival than bare-root stock in the clearcut on both seedbeds. In the strip cuts both stock types were roughly equivalent in survival. There were no consistent differences in 1982 between sheltered and bare seedspots on either seedbed.

In general, 1982 survival percentages for planted stock were higher on *Sphagnum* than on dark peat in the strip cuts but more or less equivalent on the two seedbeds in the clearcut (Table 3). In strip cuts, stocking was higher on *Sphagnum* for both seedspot treatments, whereas in the clearcut, only sheltered seed stocking was higher on dark peat.

Total and Incremental Height Growth

Uplands: For both the clearcut and the strip cuts, the planted trees were taller in 1982 than the trees originating from either bare or sheltered seedspots (sheltered trees). The 1982 average total height for all planted stock was 68.1 cm, and for the seeded trees was 20.4 cm (Table 4). In terms of height increment, the planted trees were also growing faster in 1982 than the seeded trees, the former averaging 16.3 cm per annum and the latter 6.4 cm per annum (Table 5).

On the clearcut, the bare-root stock usually performed slightly better than the paperpots in terms of total height and 1982 height increment (tables 4 and 5). Seedbed type did not appear to affect 1982 bare-root total height or height increment. However, paperpots planted on mineral soil were taller and faster growing than paperpots planted on feather moss.

On the strip cuts, the trees planted on mineral soil were taller and faster growing in 1982 than the trees planted on feather moss (tables 4 and 5).

A comparison of the two seeding methods on the clearcut site showed that both total height and height increment differed significantly, mainly because of the low values for trees of bare seed origin on the feather moss seedbed (tables 4 and 5). On the strip cut site, there were only small height growth differences among the seeding treatment/seedbed combinations.

A comparison of the two cutting methods showed that, in 1982, planted and seeded trees on the strip-cut mineral soil seedbed were generally taller and faster growing than those on the clearcut mineral soil seedbed (tables 4 and 5). On the feather moss seedbed, the paperpots were taller and faster growing in 1982 in the strip cuts than in the clearcut. The other planting/seeding methods did not show any important differences between the strip cuts and the clearcut.

Lowlands: On both the clearcut and strip cuts, planted trees had greater total height and height increment than seeded trees (tables 6 and 7). Inspection of the data collected in 1979, 1980, and 1982 revealed that height increment of the seeded trees trailed that of the planted trees by approximately two years. This lag in growth on both uplands and lowlands is

Table 4. Total height (cm) for planted stock and seedspots--upland seedbeds, clearcut and strip cuts, 1982 assessment.

Planted stock or seedspots	Clearcut	Strip cuts	Significance of 't' test
3+0 bare-root			
1. mineral soil	71.8	79.2	NS
2. feather moss	71.5	66.2	NS
408 paperpot			
3. mineral soil	60.1	76.5	NS
4. feather moss	52.8	66.8	*
Bare seed			
5. mineral soil	18.6	26.9	*
6. feather moss	7.3	20.5[a]	-
Sheltered seed			
7. mineral soil	23.7	29.2	NS
8. feather moss	21.1	16.2	NS
Significance of 'F' values.			
1,2,3,4:5,6,7,8	**	**	
1:2:3:4	NS	NS	
5:6:7:8	*	NS	

* 'F' or 't' values significant at 5% level.
** 'F' or 't' values significant at 1% level.
NS 'F' or 't' values not significant.
[a] Only one replicate contained living trees; therefore, the 't' test was not applied.

not surprising in view of the one- to four-year difference between planted and seeded trees.

On the clearcut site the dark peat seedbed produced marginally taller and faster-growing planted trees than the *Sphagnum* seedbed (tables 6 and 7). However, on the strip cuts, the planted trees were taller and faster-growing (tables 6 and 7) on *Sphagnum* than on dark peat.

There were no large differences in either 1982 total height or height increment among trees in the four seeding treatments on the clearcut site (tables 6 and 7).

Seeded trees on the four strip-cut seeding treatments performed similarly in terms of 1982 total height and height increment (tables 6 and 7). Sheltered trees from the *Sphagnum* seedbed were taller in 1982 than those from the dark peat seedbed. However, the reverse was true for trees originating from bare seed: those on dark peat were performing better than those on *Sphagnum*.

Table 5. Current annual height increment (cm) of planted stock and seedspots--upland seedbeds, clearcut and strip cuts, 1982 assessment.

Planted stock or seedspots	Clearcut	Strip cuts	Significance of 't' test
3+0 bare-root			
1. mineral soil	17.5	17.7	NS
2. feather moss	18.5	13.9	NS
408 paperpot			
3. mineral soil	15.1	19.0	NS
4. feather moss	11.9	16.7	*
Bare seed			
5. mineral soil	6.9	8.4	NS
6. feather moss	2.4	4.6[a]	-
Sheltered seed			
7. mineral soil	7.3	8.5	NS
8. feather moss	7.2	6.4	NS
Significance of 'F' values			
1,2,3,4:5,6,7,8	**	**	
1:2:3:4	NS	NS	
5:6:7:8	*	NS	

* 'F' or 't' values significant at 5% level.
** 'F' or 't' values significant at 1% level.
NS 'F' or 't' values not significant.
[a] Only one replicate contained living trees; therefore, the 't' test was not applied.

In three of the four dark peat planting and seeding combinations total height and height increment were higher on the trees in the clearcut than in the strip-cut areas (tables 6 and 7). On the *Sphagnum* seedbed, both planted and seeded trees had slightly higher 1982 height increment on strip cuts than on the clearcut.

Uplands and lowlands: Generally, the planted trees were taller and were growing faster in 1982 on the upland than on the lowland sites (tables 4, 5, 6, and 7). In the seeding treatments there were no distinct differences in height growth between uplands and lowlands.

Vegetative Competition

Vegetational assessments were undertaken five years after cutting on both the clearcut and strip-cut areas as part of an associated study (Jeglum 1980). It was evident from these data that the percentage cover of vegetation was generally lower on the upland than on the lowland site type (Table

Table 6. Total height (cm) of planted stock and seedspots--lowland seedbeds, clearcut and strip cuts, 1982 assessment.

Planted stock or seedspots	Clearcut	Strip cuts	Significance of 't' test
3+0 bare-root			
1. dark peat	64.4	57.8	NS
2. *Sphagnum*	59.9	62.3	NS
408 paperpot			
3. dark peat	62.0	46.0	*
4. *Sphagnum*	60.4	53.9	NS
Bare seed			
5. dark peat	20.9	24.6	NS
6. *Sphagnum*	18.9	19.1	NS
Sheltered seed			
7. dark peat	27.1	18.6	NS
8. *Sphagnum*	20.1	24.6	NS
Significance of 'F' values.			
1,2,3,4:5,6,7,8	**	**	
1:2:3:4	NS	*	
5:6:7:8	NS	NS	

* 'F' or 't' values significant at the 5% level.
** 'F' or 't' values significant at the 1% level.
NS 'F' and 't' values not significant.

8). For example, the percentage cover of graminoids (grasses and sedges) and living *Sphagnum* increased from the upland to lowland site types on both clearcut and strip cut sites.

Cover values for vegetative components (Table 8) suggest that the greatest competition came from shrubs, followed by herbs and graminoids. The most abundant shrubs were *Alnus rugosa, Rubus idaeus, Ledum groenlandicum,* and *Vaccinium* species; abundant herbs included *Cornus canadensis, Aster macrophyllus, Clintonia borealis, Epilobium angustifolium,* and *Smilacina trifolia.* Total shrub and herb cover differed little between lowlands and uplands, or between the clearcut and the strip cuts. However, graminoids were definitely more numerous in both the lowland and upland strip cuts than in the clearcut. The heavier graminoid cover in the strip cuts may be due to the generally moister conditions there than in the clearcut. Live feather mosses were also more plentiful in strip cuts, and this suggests that some shading may have been beneficial to them.

Table 7. Current annual height increment (cm) of planted stock and seedspots--lowland seedbeds, clearcut and strip cuts, 1982 assessment.

Planted stock or seedspots	Clearcut	Strip cuts	Significance of 't' test
3+0 bare-root			
1. dark peat	12.8	9.3	NS
2. *Sphagnum*	10.9	12.2	NS
408 paperpot			
3. dark peat	13.2	9.2	NS
4. *Sphagnum*	10.7	11.2	NS
Bare seed			
5. dark peat	7.4	9.9	NS
6. *Sphagnum*	6.4	7.6	NS
Sheltered seed			
7. dark peat	8.9	7.0	NS
8. *Sphagnum*	5.8	7.6	NS
Significance of 'F' values.			
1,2,3,4:5,6,7,8	**	*	
1:2:3:4	NS	NS	
5:6:7:8	NS	NS	

* 'F' or 't' values significant at the 5% level.
** 'F' or 't' values significant at the 1% level.
NS 'F' and 't' values not significant.

Table 8. Percentage cover of main vegetation types occurring on uplands and lowlands in clearcut and strip cut areas. Upland site types consist of upper slopes and crests combined. Lowland site types consist of lower slopes and drainageways combined.

	Clearcut		Strip cuts	
Vegetation types	Uplands	Lowlands	Uplands	Lowlands
Shrubs	22.9	22.5	19.3	20.9
Graminoids	1.4	6.4	4.2	19.2
Herbs	9.8	7.3	8.0	11.4
Feather moss (live)	2.7	6.1	18.4	8.7
Sphagnum (live)	0.0	2.8	0.4	1.4
Pioneer mosses	0.6	8.2	4.3	2.4

Table 9. Percentage of *original* planting spots and seedspots (combined) with graminoids as the principal vegetative competition, 1979 and 1982 assessments.

	Clearcut		Strip cuts	
Seedbeds	1979	1982	1979	1982
Uplands				
Mineral soil	1.0	0.8	14.9	16.9
Feather moss	1.3	0.5	5.2	4.0
Lowlands				
Dark peat	46.5	40.4	74.2	57.5
Sphagnum	42.0	32.1	37.3	31.6

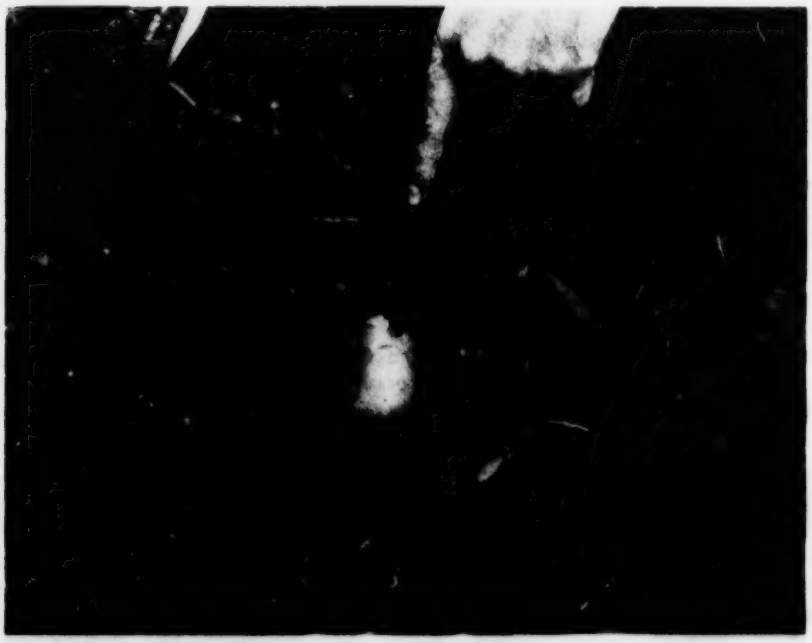


Figure 6. Seed shelter completely engulfed by living *Sphagnum* moss after five growing seasons.

On the dark peat seedbed, there was more vegetative competition in the strip cuts than in the clearcut, owing to the higher frequency of graminoids (Table 9). On both the clearcut and the strip cuts, graminoids were the dominant form of vegetative competition more often on dark peat than on *Sphagnum*. The principal species of graminoids included *Calamagrostis canadensis*, *Carex trisperma*, *Carex vaginata*, and *Scirpus cyperinus*.

On both clearcut and strip-cut areas a high percentage of *Sphagnum* planting and seeding spots was completely covered by living *Sphagnum*. This moss often completely engulfed the seed shelters (Fig. 6) and sometimes even smothered the planted seedlings.

DISCUSSION

The fact that seedspot stocking, both bare and sheltered, on mineral soil was higher on strip cuts than on the clearcut may be explained by the protection from drying and exposure provided by the adjacent forested leave strips (Table 2). This may also explain the greater height growth of planted and seeded trees on the strip cut than on the clearcut mineral soil seedbed (tables 4 and 5).

There are at least two other possible explanations for differences in stocking results. First, there was a two-week delay between seeding on the clearcut and seeding on strip cuts. Second, the clearcut site could have been somewhat higher and drier on average than the strip cuts. The height growth results from planted stock could have been influenced only by the second factor, because both stock types were planted on the clearcut and strip cuts at about the same time.

In both planted and seeded treatments survival or stocking was always higher on the mineral than on the feather moss seedbed (Table 2). These differences were greater in the seeded than in the planted trees. The mineral soil generally produced taller, faster-growing trees (tables 4 and 5). Once the protective forest cover had been removed from the clearcut and strip-cut areas the feather moss dried quickly, becoming an extremely poor seedbed and a less than ideal planting spot.

Richardson (1972), in a seedspotting study with black spruce in Newfoundland, showed that fresh to very fresh sites with organic matter depths of 1.27 cm or less provided the most satisfactory conditions for germination and establishment of seedlings. These conditions were frequently associated with a *Dicranum* or *Polytrichum* moss seedbed. In this experiment the fresh upland mineral soil seedbeds yielded the best stocking for both types of seedspot.

The use of seed shelters generally increased stocking on the mineral soil upland seedbed, where exposure may have caused mortality among succulent young germinates (Table 2). Sheltering the seed was particularly beneficial in the open clearcuts. Even with sheltering, stocking remained extremely low on the feather moss seedbed. On the lowlands, sheltering the seed increased stocking only marginally on the dark peat seedbed (Table 3).

The interpretation of survival and height growth results on the lowlands was complicated by several factors, including flooding and vegetative competition. The dark peat seedbeds in strip cuts were wetter than those in the clearcuts. In fact, some of the seedspots were observed to be covered with water during some assessments. The fact that grass and sedge

development were generally greater in the strip cuts than in the clearcut was possibly due to these wetter conditions and/or the higher original composition of graminoids.

In the strip cut area the fact that graminoid competition was more severe on the dark peat than on the *Sphagnum* seedbeds (Table 9) may have accounted for lower survival, stocking, and height growth of trees on the dark peat seedbed: surrounding soil and air temperatures may have been reduced through shading, root competition may have been increased, and snow-laden vegetation may have smothered the trees (McMinn 1981). Aksamit and Irving (1984) have noted that graminoid competition can be detrimental to black spruce establishment. Flooding on the low-lying dark peat seedbeds also had a negative effect on tree performance. The higher stocking levels on the strip cuts than on the clearcut *Sphagnum* seedbed (Table 3) may be due to the increased protection provided by the forested leave strips, to differences in seeding time, or to differences in the *Sphagnum* seedbed. The fact that height performance of the trees originating from bare seed on dark peat was better than that of trees originating from bare seed on *Sphagnum* seedbed (tables 6 and 7) may be explained by nutrient supply and soil temperature differences.

The graminoid cover on the clearcut was lighter than that on the strip-cut dark peat seedbed (Table 9) possibly because the clearcut was generally a more elevated, drier site. Survival, stocking, and tree height growth were greater on the dark peat seedbed on the clearcut than on the strip cuts (tables 3, 6, and 7). This may be due to somewhat drier conditions, as well as to less graminoid competition. Better tree growth on dark peat than on *Sphagnum* in the clearcut was possibly due to nutrient supply and increased soil temperature.

Height growth of planted trees was better on the upland areas than on the lowland areas, in part because of the lower vegetative cover on the upland areas. However, it is unclear why the trees originating from bare and sheltered seedspots on both the upland and lowland sites were approximately equivalent in both total height and height increment in 1982.

The lack of frost heaving in the paperpots planted on the mineral soil seedbed in this trial may be explained by the covering of some seedbeds by a thin layer of organic matter. In another study in the Lake Jean area (Fig. 1), 36% of paperpots planted on exposed mineral soil heaved to some degree within the first year after outplanting.[3] Frost heaving and erosion can be problems on lowland dark peat seedbeds (Jeglum et al. 1983), although they were not noted in the present experiment.

At the time of outplanting, the average shoot lengths of the 3+0 bare-root and paperpot stock were 33.4 and 17.4 cm, respectively (Table 1). However, by the time of the last assessment (1982) there were very few large differences in either total height or height increment between the bare-root and paperpot trees (tables 4, 5, 6, and 7). After five growing seasons, the average total height of the bare-root stock and paperpot stock was 66.6 and 59.8 cm, respectively. The paperpots had greater height increment than the bare-root stock for two years on the clearcut area and for three years on the strip-cut area, immediately

[3] Mason, J. and Copis, P. 1976. Effects of soil moisture on survival and growth of outplantings of black spruce seedlings in paperpots. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. File Rep., 20 p. (unpubl.).

following outplanting. The poor root system of the bare-root stock at outplanting may have contributed in part to the slower initial growth of this stock type (Table 1). However, the early height growth advantage of black spruce paperpot stock over bare-root stock has been well documented in the past (Krause 1982, Mattice 1982, Scarratt 1982, Scarratt and Wood 1982, Alm 1983) and has been observed to last up to five years from outplanting.

In this experiment, fifth-year survival was always higher for the paperpot trees than for the bare-root trees on similar seedbeds (tables 2 and 3).

The seed shelters used in this experiment were designed to decompose after a few years in the field. In this trial, after five growing seasons on both uplands and lowlands, 7.3% of the cone shelters were still intact with no visible sign of decomposition. On average, 32.2% of the shelters were well decomposed. The remaining shelters were either partially decomposed or missing. The various seeding treatments (cutting method, site, and seedbed types) did not appear to influence shelter condition.

CONCLUSIONS AND RECOMMENDATIONS

1. On site types similar to those tested, planting of either paperpot or bare-root stock is a surer method of regenerating harvested leave strips than spot seeding.

2. After five growing seasons the paperpot stock had slightly higher survival rates than the bare-root stock, and the two were almost equal in total height. It is therefore recommended that under similar conditions the forest manager plant either container stock of adequate grade or morphologically well balanced bareroot stock. We suggest 1.5 + 1.5 transplant stock owing to its higher root area index.

3. Regeneration by seeding is a practicable option on mineral soil uplands. The seeding technique should not be used on feather moss. Our results suggest that competition and flooding can reduce the effectiveness of this approach on lowlands.

4. On the upland site, mineral soil was superior to feather moss for planting and particularly for seeding. Prior to seeding or planting it is recommended that the forest manager ensure that sufficient planting or seeding spots are free of feather moss.

5. In this trial, container stock and bare-root stock on mineral soil were not affected by frost heaving. However, the risk of heaving may be reduced by ensuring that a thin layer of well decomposed organic matter remains intact on the planting spot.

6. It is possible that the sheltering influence of the leave strips improved seedspot stocking, and planted and seeded tree height growth, on mineral soil seedbeds.

7. The use of seed shelters resulted in increased stocking on the upland mineral soil seedbed. There were some slight increases in stocking on the other seedbeds, but these may not be enough to warrant the use of shelters.

8. On the strip cuts the dark peat seedbed was subjected to heavy graminoid competition and flooding. These conditions were not as evident on the clearcut site, and therefore survival, stocking, and height growth

were correspondingly higher than on the strip cuts. However, we hesitate to recommend dark peat as a seedbed or planting spot owing to its liability to frost heaving, erosion, and the potential for rapid invasion by competing vegetation.

LITERATURE CITED

AKSAMIT, S.E. and IRVING, F.D. 1984. Prescribed burning for lowland black spruce regeneration in Minnesota. Can. J. For. Res. 14: 107-113.

ALM, A.A. 1983. Black and white spruce plantings in Minnesota: container vs. bareroot stock and fall vs. spring planting. For. Chron. 59(4):189-191.

FRASER, J.W. 1980. The black spruce regeneration problem. p. 2 *in* C.A. Plexman, *Ed.*, Forestry Research Newsletter, Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Fall-Winter 1980.

JEGLUM, J.K. 1980. Strip cutting in shallow-soil upland black spruce near Nipigon, Ontario. I. Study establishment and site conditions. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-315. 61 p + Appendices.

JEGLUM, J.K. 1982. Strip cutting in shallow-soil upland black spruce near Nipigon, Ontario. II. Regeneration in the first study area. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-337. 24 p.

JEGLUM, J.K. 1983. Changes in tree species composition in naturally regenerating strip clearcuts in shallow-soil upland black spruce. p. 180-193 *in* R.W. Wein, R.R. Riewe, and I.R. Methven, *Ed.*, Conf. Proc. Resources and Dynamics of the Boreal Zone, Thunder Bay, Ont., Aug. 1982, Assoc. Can. Univ. for Northern Studies.

KETCHESON, D. 1982. The impact of strip cutting on logging costs. Pulp and Paper Can. 83(7):42-46.

JEGLUM, J.K., HAAVISTO, V.F. and GROOT, A. 1983. Peatland forestry in Ontario: an overview. p. 127-167 *in* J.D. Sheppard, J. Musial and T.E. Tibbetts, *Ed.* Symposium '82, a symposium on peat and peatlands. Sponsored by the Gov't of Can., Gov't of New Brunswick, Econ. Expansion Commission of the Peninsula Inc., and Can. Natl. Committee, Internat'l Peat Society.

KRAUSE, H.H. 1982. Early growth of bare-root and paperpot plantations at various locations in New Brunswick. p. 335-366 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, *Ed.* Proceedings of the Canadian Containerized Tree Seedling Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-10.

MATTICE, C.R. 1982. Comparative field performance of paperpot and bare-root planting stock in northeastern Ontario. p. 321-330 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, *Ed.* Proceedings of the Canadian Containerized Tree Seedling Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-10.

MORRISON, I.K. and ARMSON, K.A. 1968. The rhizometer, a device for measuring roots of tree seedlings. For. Chron. 44:21-23.

McMINN, R.G. 1981. Ecology of site preparation to improve performance of planted white spruce in northern latitudes. Paper presented at Third Annual Workshop, International Committee on Regeneration of North Latitude Forest Lands, IUFRO W.P. S1 .05-.08 (Natural stand Regeneration), Prince George, B.C. 30 August -1 September 1981.

REESE, K.H. and SADREIKA, V. 1979. Description of bareroot shipping stock and cull stock. Ont. Min. Nat. Resour., For. Resour. Br., Toronto, Ont. 39 p.

RICHARDSON, J. 1972. Seedspotting black spruce throughout the growing season. Dep. Environ., Can. For. Serv., St. John's, Nfld. Inf. Rep. N-X-69. 16 p.

ROWE, J.S. 1972. Forest regions of Canada. Dep. Environ., Can. For. Serv., Ottawa, Ont. Publ. No. 1300, 172 p.

SCARRATT, J.B. 1982. Container stock specifications for northern Ontario. p. 343-354 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, *Ed.* Proceedings of the Canadian Containerized Tree Seedling Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. 0-P-10.

SCARRATT, J.B. and WOOD, J.E. 1982. Development and evaluation of container planting methods. p. 6-8 *in* C.A. Plexman, *Ed.* Forestry Research Newsletter. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Summer 1982.